Risk assessment of desertification using GIS in parts of Mond Basin, Southern Iran

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ABSTRACT

The present paper attempts to evolve a new model by considering various indicators of different types of land degradation or desertification, namely, water erosion, soil salinity, vegetation degradation, and lowering of ground water table. The Mond river basin, located centrally to this zone, has been selected as a test area to assess the risk and kind of desertification. For this purpose two sub basins of the Payab and Qareh Aghaj have been chosen for detailed study. The thresholds for the severity classes of indicators have been established and then the hazard map for each indicator of types of desertification has been prepared in a GIS. The risk maps of water erosion, soil salinization, lowering of water table, vegetation degradation have been produced for each of the two sub basins. It was possible to distinguish the areas under ‘actual risk’ from areas under ‘potential risk’ of desertification types. Also areas under potential risk are classified to subclasses with different probability level to show a statistical picture of risk in future. The final map of risk of desertification is produced by overlaying all four maps of degradation types. Between the two basins the overall environmental condition in the Payab sub basin is worse. Results show that potential risk areas are much widespread than areas under actual risk in the upper reaches (Qareh Aghaj sub basin) of Mond basin, indicating further threat of land degradation or desertification in future. While per cent areas under actual risk are much extensive in the lower reaches (lower reaches), indicating the higher degradation at present.

Key words: Desertification, GIS, Indicator, Actual Risk, Potential Risk.

INTRODUCTION

In the early 1990s, desertification was defined as 'land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities' (UNEP, 1992). Desertification involves a complex set of factors, interacting in space and time leading to a decrease in land productivity. Iran lies within the arid and semi arid climatic belt, and in such climatic conditions the desertification processes are known to progress more speedily and pervasively.
Different models for assessing desertification and land degradation have been used like the “Provisional Methodology for Assessment and Mapping of Desertification Hazard” which was the first major exercise (FAO/UNEP, 1984). Another important model is the MEDALUS (Kosmas et al., 1999) which identifies regions that are environmentally sensitive areas (ESAs) to desertification. Some other important models are GLASSOD, ASSOD and recently LADA.
This paper attempts at evolving a model for assessing risk of land degradation in southern part of Iran. For this purpose the Mond river basin for which enough data were available for variability in climate and land degradation types has been chosen. The present work has given the opportunity to compare the intensity of different types of land degradation related to the two sub basins of Qareh Aghaj (upper reaches of Mond River) and Payab sub basin (lower reaches of Mond River) which differ in elevation, climate and status of degradation.

The total area covered in the GIS analysis is 1,787,000 ha**.**

METHODS

The data for this study have been gathered from the records and reports published by the different departments of the Ministries of Agriculture and Energy and the Meteorological Organization of Iran. The main types of data are on physiography, geology, soil, hydrology, vegetation and climate and on some causes related to human activity such as over grazing, over pumping and density of population. In this research several different indicators have been selected to achieve the best model for assessing the risk of water erosion, soil salinization and vegetation degradation and lowering of water table in both the sub basins of the Mond Basin. The status map of wind erosion has also been prepared. The recommendations like by the FAO and other scientists and also the statistical parameters of the present data for local conditions have been considered for producing hazardous thresholds of the indicators, revealing 'none' to 'very severe' hazardous conditions (ratings scores between 1 to 5) to assess the risk of these types of degradation. Table 1 shows an example for this kind of classification for indicators used for water erosion.

The hazard maps have been prepared in the GIS for each indicator. To project the effect of all the indicators the hazard maps for each type of land degradation were overlaid in the GIS using the following equations, giving proper weighting for each indicator:

Risk score for water erosion = ((Soil depth + Slope + Status of water erosion) × 2) + Erodibility of surface geology + Intensity of rainfall + Annual rainfall + Soil erodibility + Vegetation cover + Bare ground
Risk score for soil salinization = (Status of soil salinity × 2) + Efficacy of surface geology + Quality of irrigation water + Depth of water table + Ground water quality + Soil texture + Climate + Dry index + Slope
Risk score for vegetation degradation = ((Potential of biomass production + Vegetation cover + Rural population density + Pressure of livestock) × 2) + Expansion of agricultural activity over lands suitable for natural resources + Villages density + Climate + Coefficient variation (CV) of annual rainfall + Land suitability for vegetation cover
Risk score for lowering of ground water table = ((Annual rainfall + Hydrogeology of plains + Over evacuation + Increased consumption of ground water in the 10 years + Surface water consumption + Average water consumption in irrigated areas) × 2) + Ratio of non irrigated areas to irrigated areas + Ratio of water evacuation from qanats to that from wells + Climate + Coefficient variation (CV) of annual rainfall + Influence of carbonate formations.

The risk score arrived at enabled to subdivide the severity classes of degradation types. Five such severity classes ranging from 'none' to 'very severe' were recognized (Table 2). The GIS analysis enabled the distinction of areas under 'actual risk' from areas under 'potential risk' of land degradation types. The actual risk areas show at present a state of degradation equal to or worse than the classes assigned for the risk. Areas under potential risk have been recognized using the following criteria:
A] Potential risk area = areas where the risk class determined > present status of hazard.

For calculating the probability for potential risk, the risk scores have been converted to percentage. The following equation was used for this purpose:

$$\text{\% Probability of Risk in Potential Risk Areas} = \frac{X - a}{b} \times 100, \text{ where}$$

a: the least score (0% probability) for each type of land degradation in Table 2, b: the numeric difference between the highest and the least scores for each type of land degradation in Table 2, and X: the risk score in each polygon

The final map of risk of land degradation is produced by overlaying all four maps of degradation types.

Indicators	Class limits and their ratings score				
	None (1)	Slight (2)	Moderate (3)	Severe (4)	Very severe (5)
1)Soil erodibility	<0.1	0.1 - 0.19	0.2 - 0.34	0.35 - 0.49	≥ 0.5
2) Soil depth, cm	Very deep or ≥ 150 cm	Deep or 90-149 cm	Semi deep to deep or 50-89 cm	Shallow to semi deep or 10-49 cm	Very shallow to shallow or <10 cm
3) Per cent slope	<2	2-4	5-14	15-29	≥ 30
4) Intensity of rainfall *	<10	10-19	20-29	30-39	≥ 40
5) Total rainfall, mm	<50	50-199	200-399	400-599	600-1000
6) Per cent bare ground	<20	20-39	40-59	60-79	≥ 80
7) Per cent vegetation cover	≥ 70	50-69	25-49	10-24	<10
8) Status of water erosion	Features of erosion insignificant	Sheet and rill erosion and occasional gully erosion visible	Sheet and rill erosion moderate and occasional gully erosion visible	Fairly high abundance of features of sheet, rill and gully erosion	Highly abundant sheet, rill and gully erosion (badlands)
9) Erodibility of Surface geology	Formations resistant against water erosion and thick alluvial deposits of plains.	Formations fairly resistant against water erosion	Formation with moderate resistance against water erosion	Formations with low resistance against water erosion	Formations susceptible to water erosion like salt domes associated with layers of marl, shale.

Table 1. The indicators used in the model of risk assessment for water erosion.
*Average of maximum for amount of rainfall in mm during 6 hours for period of 2 years

Table 2. Severity classes in the Risk Maps and GIS models regarding the scores of polygons

Risk type	Class limits and their score in the GIS				
	None	Slight	Moderate	Severe	Very severe
1) Water Erosion	12 - 18	18.1 - 30	30.1 - 42	42.1 - 54	54.1 - 60
2) Soil Salinization	10 - 15	15.1 - 25	25.1 - 35	35.1 - 45	45.1 - 50
3)Vegetation Degradation	13 -19.5	19.6 – 32.5	32.6 – 45.5	45.6 – 58.5	58.6 - 65
4) Lowering of Ground Water Table	17 – 25.5	25.6 – 42.5	42.6 – 59.5	59.6 – 76.5	76.6 - 85

RESULTS AND DISCUSSION

In the present work, the risk assessment of desertification attempts to demarcate areas with greater probability of reaching the worst step of degradation like a change from moderate to severe state of erosion and also measure the probability (risk) of this adverse change. This kind of classification using two categories of ‘actual risk’ and ‘potential risk’ and its subclasses based on per cent probability in the risk maps is the first attempt of its kind for defining areas with higher risk of degradation. The risk map of water erosion is one example of this kind of methodology for assessing risk of land degradation types (Fig. 1).

To qualify the severity classes of desertification map, the maximum degree of risk among the four types of land degradation shown in each polygon was selected. Once again from these maps (Fig. 2) the areas under actual risk and areas under potential risk were identified. From the Fig. 2, it is concluded that in both sub basins areas under actual risk are more widespread compared to areas under potential risk. Among severity classes a greater proportion (52%) of land is under ‘moderate risk’ in the Qareh Aghaj sub basin while the in the Payab it is 83% under ‘severe risk’. This implies the obvious that the conditions in the

Payab sub basin with arid climate are worse compared to the Qareh Aghaj sub basin, with semi arid climate.On the other hand, the vulnerable potential risk areas under the threat are more extensive in the Qareh Aghaj (25 %) compared to the Payab (6%). These results indicate that the already degraded lands with worse condition are lesser in the Qareh Aghaj sub basin and therefore they need more attention for protection against future degradation. Also GIS analysis shows the main type of desertification in the plains and high lands of both sub basins is the vegetation degradation. This reflects the overall impacts of climatic and anthropogenic causes and soil degradation on the vegetation cover.

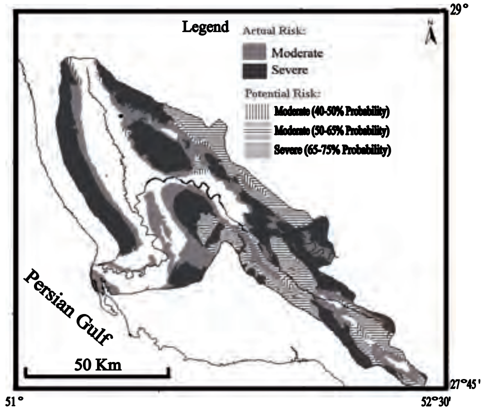

Figure 1. Risk of water erosion in the Payab sub basin

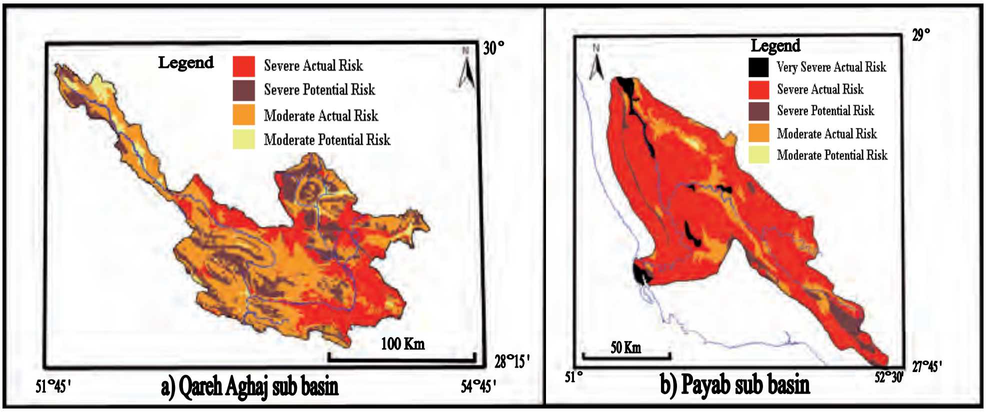

Figure 2. Risk of desertification in the study area.

CONCLUSIONS

The Mond Basin model is the first attempt of its kind for defining the risk of desertification and can be made applicable for other areas in Iran and elsewhere. The hazard maps of different indicators processed in the risk assessment model give a far better opportunity to distinguish the severity classes of risk of desertification. The model based on the statistical parameters helps to identify the areas under actual and potential risk and their sub classes based on per cent probability. The potential risk areas in the Qareh Aghaj sub basin are more widespread compared to the Payab, indicating further threat of land degradation in future although between the two basins the overall environmental condition in the Payab sub basin is worse.

REFERENCES

- FAO/UNEP .1984. *Provisional methodology for assessment and mapping of desertification*. Food and Agriculture Organization of the United Nations, Rome, 84p.
- Kosmas, C., Poesen, J., & Briassouli, H. 1999. *Key indicators of desertification at the Environmentally Sensitive Areas (ESA) scale*, *The Medalus Project: Mediterranean Desertification and Land Use. Manual on Key Indicators of Desertification and Mapping Environmentally Sensitive Areas to Desertification*. Project report. European Commission.
- UNEP (United Nations Environmental Program) .1992. *World Atlas of Desertification*, editorial commentary by N. Middleton and D.S.G. Thomas. Arnold: London.